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COMPARATIVE STUDY ON PERFORMANCE EVALUATION OF SOLAR PHOTOVOLTAIC MODULE UNDER MANUAL TRACKING AND FIXED ORIENTATION MODE

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ABSTRACT

Solar photovoltaic module is the most significant renewable energy technology as it involves direct conversion of solar radiation into electricity. Several solar cells are connected in series/parallel configuration to make it module in order to obtain desired voltage and current. In photovoltaic effect, Photons give their energy to electrons based on the conservation of momentum and energy principals. The liberated electrons can move across the crystal. The experiment was carried out to evaluate the performance of solar module under different condition using solar photovoltaic test kit procured from IIT, Mumbai. The poly crystalline module of 10 watt was tested for two modes (i) manual tracking of module to follow the sun from east to west (ii) Fixed orientation. For both condition the angle of inclination was kept constant at Latitude +10^0 i.e. $34^0$19'. The result revealed that manually tracking of module recorded maximum power (10.23 W) even under moderately low solar insolation of 1107 W/m^2as compared to module under fixed mode condition.

KEYWORDS: Current, Module, Power, Solar Radiation, Volt

INTRODUCTION

With about 300 clear, sunny days in a year, India's theoretical solar power reception, on only its land area, is about 5000 Pete-watt-hours per year (PW/yr.) (i.e. 5,000 trillion kWh/yr. or about 600,000 GW). The daily average solar energy incident over India varies from 4 to 7 kWh/m^2 with about 1,500–2,000 sunshine hours per year (depending upon location), which is far more than current total energy consumption. For example, assuming the efficiency of PV modules were as low as 10%, this would still be a thousand times greater than the domestic electricity demand projected for 2015. Solar cell is the basic building block to generate energy from solar energy. Because of the very less capacity of individual cell, many cells are connected in series/parallel configuration to achieve desire voltage and power. The arrangement of cells is called module.

Role of Atmospheric Parameters on Performance of Solar Module: Photovoltaic (PV) module performance is difficult to predict due to variation in atmospheric factors and nonlinear performance characteristic of various module technologies Manufacturers, distributors and developers typically sell PV on a cost per peakwatt (Wp). basis. A module's Wp rating, also known as its Pmax, is based on its performance under Standard Test Conditions (STC) consisting of 1000W/m2, 1.5 AM and 25°C module temperature. However this condition rarely occurs simultaneously in nature and the performance of PV materials over time and by geographical location.

The International Electro technical Commission (IEC) has proposed PV rating standard (IEC61853) that include

characterization module performance based on a matrix of various weather condition, including high temperature conditions (HTC), STC, nominal cell temperature (NOCT), low temperature conditions (LTC) and low irradiance conditions (LIC). Note that IEC618531 does not include evaluating performance under photo voltaics for utility scale applications test conditions (PVUSA or PTC) of 1000W/m2, 20°C ambient temperature, wind speed of 1 meter/second and 1.5 AM. The experiment was conducted with a view to evaluate the influence of atmospheric factors on net power realization of solar photovoltaic module under manual tracking mode

MATERIAL AND METHODS

The study was under taken using solar photovoltaic test kit exist in the solar lab of the college of Renewable Energy and Environmental Engineering, Sardarkrushinagar, Dantiwada Agricultural University Sardarkrushinagar, Dist.: Banaskantha, in the State of Gujarat. The location is situated on the geographical latitude of $24^0$19’ N and longitude 72^0 19’ E. The module was exposed to solar radiation and other atmospheric factors i.e. wind, temperature to gauge the effect of it on performance of solar module under two situation (i) manual tracking of module to follow the sun from east to west (ii) Fixed orientation. For both condition the angle of inclination was kept constant at Latitude $+10^0$ i.e. $34^0$19’.

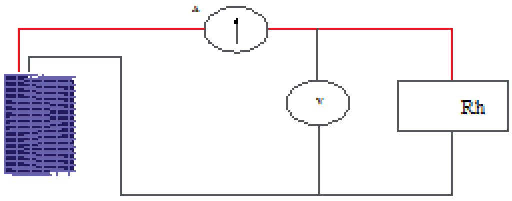

Figure 1: Circuit Diagram of Single Photovoltaic Module

Instruments

To record atmospheric and electrical parameters the instruments used in the experiment were pyranometer, sunshine recorder, digital thermometer, anemometer, hygrometer and multi meter

Figure 2: Experimental Setup

Terminals and Connections

The positive and negative terminals of each of the PV module are provided with banana connectors, to connect the modules in series and or in parallel. extra banana connectors and crocodile clips are provided with this kit.3.

Measured Parameters

The various parameters studied during the parameters comprising of short circuit current (I_{sc}), open circuit voltage (V_{oc}), Fill Factor (FF), Efficiency (), peak power (P_m), series Resistance (R_s) and Shunt Resistance (R_{sh}).

Calculation

Following formulas were utilized to differentiate the two operating condition of module

$$FF = \frac{Vm \times Im}{Voc \times Isc}\%$$

Where FF=Fill Factor in percentage , the Fill Factor (FF) is defined as the sureness of the I-V curve and mainly related to the resistive loss in a solar module. It can be defined as the Ratio of the actual maximum power output to the ideal maximum power output. Where Vm= maximum voltage

Im= maximum current, Voc= Open Circuit voltage, Isc = Short circuit current

PV module efficiency can be estimated using following equation:

$$\textbf{PV Module Efficiency} = \frac{\textbf{(Measured Wp)}}{\textbf{(Instantaneous Radiation} \times \textbf{Module Area)}}$$

PV module efficiency depends on many parameters like solar radiation, temperature, area, cell technology etc. In practical, The PV module efficiency changes every time due to change in any of the already discussed parameters (solar radiations, temperature, area, cell technology). Therefore in order to find out the PV module efficiency instantaneous input solar radiation and instantaneous PV module peak power was measured. Since both radiation and peak power was keep changing during the time of measurements, PV module efficiency was measured few times during the measurement and average value of PV module efficiency was used

RESULT AND DISCUSSION

This chapter deals with the result obtained for two modes of poly crystalline solar module under different atmospheric condition and module angle of inclination $34^0 19'$.

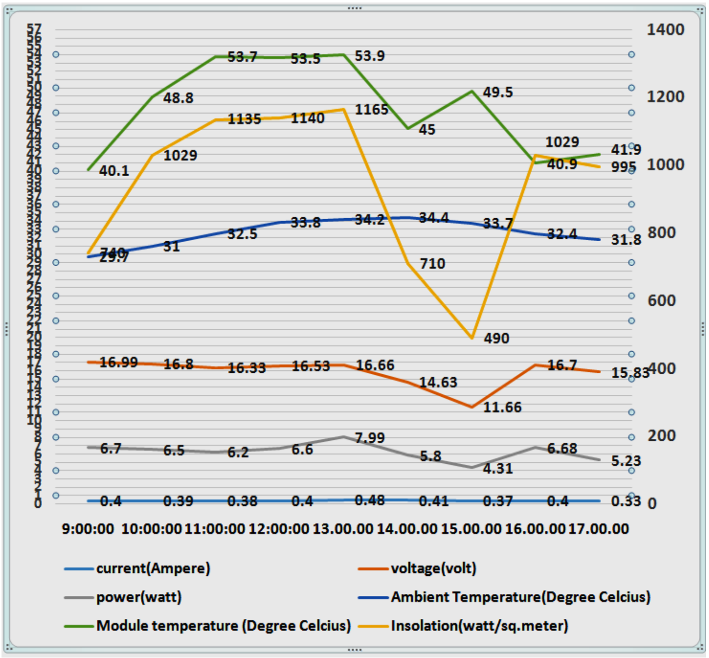

Figure 3: Performance of Poly Crystalline Single Module Under Fixed Orientation in South Facing Mode (Average of 10 Days)

Figure 3 shows that maximum power generation of 7.99 W was recorded at 13:00hrs. When ambient temperature, module temperature and insolation were 34.2^{0}C 53.9^{0}C and 1165W/m^{2}respectively. Minimum power of 4.31 W was monitored at 15:00 hrs., when ambient temperature, module temperature and insolation were 33.7^{0}C, 49.5^{0}C and 490W/M^{2}respectively. Average power of 6.2 W was observed at 11:00 hrs. When ambient temperature, module temperature and insolation were 32.5^{0}C, 53.7^{0}C ^{0}C and 1135 W/M^{2}The result revealed that current, voltage and power co-relate with the solar insolation and temperature.

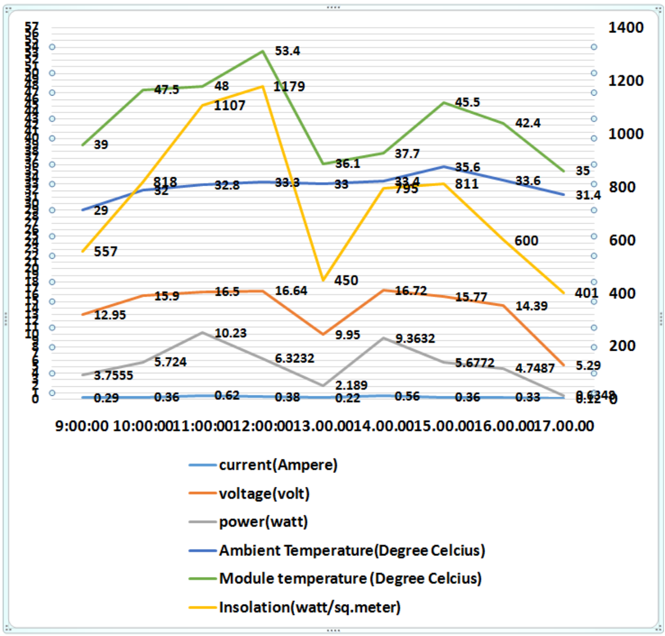

Figure 4: Performance of Poly Crystalline Single Module under Manual Tracking Mode (Average of 10 Days)

Figure 4 shows that maximum power generation of 10.23 W was recorded at 17:00 hrs. When ambient

temperature, module temperature and insolation were 32.8^{0}C and 1107W/m^{2}respectively. Minimum power of 0.634 W was monitored at 15:00 hrs, when ambient temperature, module temperature and insolation were 31.4^{0}C and 410 W/M2respectively. Average power of 4.74 W was observed at 16:00 hrs. When ambient temperature, module

CONCLUSIONS

The result revealed that manually tracking of module recorded maximum power (10.23 W) under solar insolation of 1107 W/m^2 as compared to module under fixed mode condition. The better performance of poly crystalline module under manual tracking was attributed to solar radiation striking normal to the module surface all through the day. Overall 22% more net realization in power was found for manually tracked poly crystalline module as compared to module under fixed mode condition.

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